# Modelling the direct radiative effect of wildfire smoke on a severe thunderstorm event with the HARMONIE model

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## Introduction

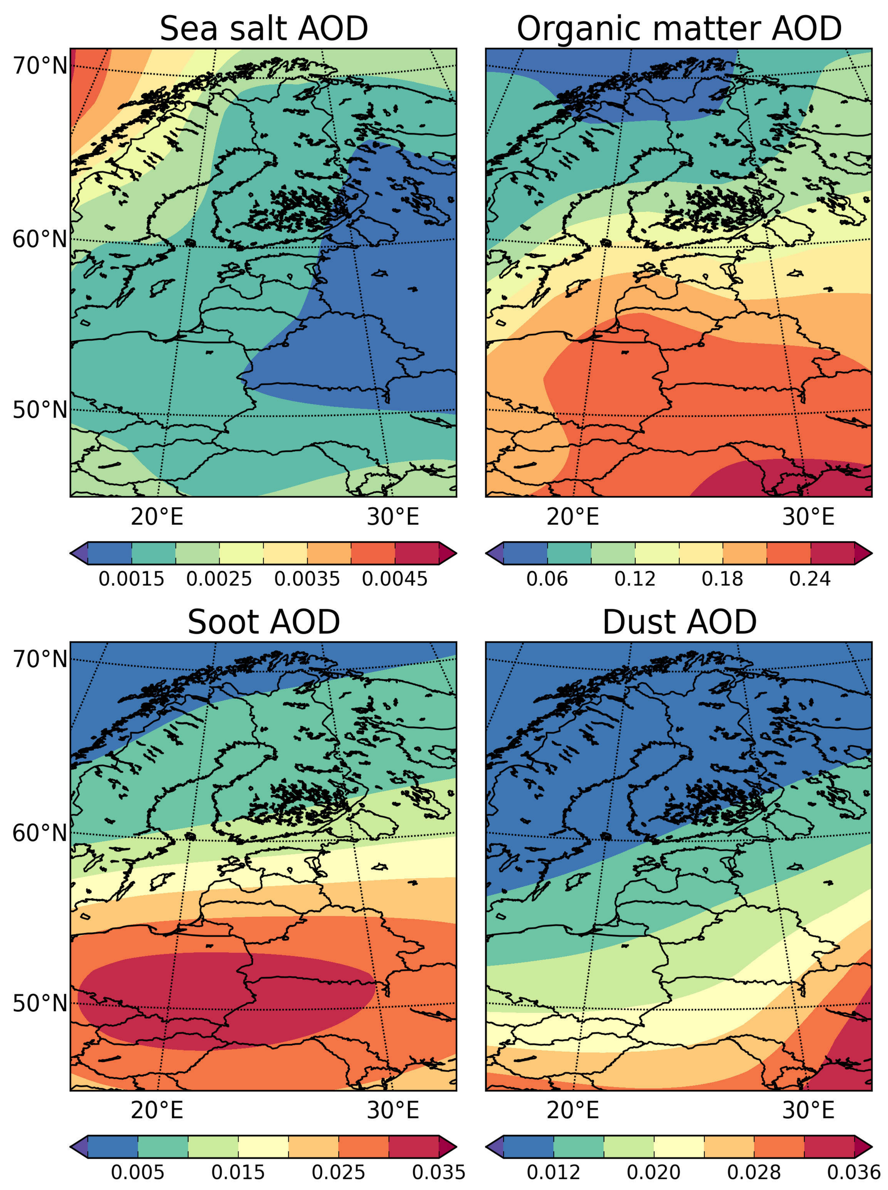


**Figure 1.** Climatological aerosol distributions in the HARMONIE model in the Baltic Sea region.

*) Severe thunderstorm coincided with forest fires in the Baltic Sea region on 08.08.2010. Radiative forcing of the smoke is studied.

*) Default model set up assumes static climatological distribution of aerosols (Tegen et al., 1997).

*) Dynamic AOD fields are introduced instead of climatological (linear interpolation in time of 3-hourly input AOD between time steps, no advection of aerosols in HARMONIE).

*) Climatological vertical profile of aerosols is assumed as first approximation to distribute aerosol on vertical levels.

## Model set up

*) HARMONIE 37h1.1 (AROME physics, 2.5 km horizontal resolution, 1 min timestep).

*) 1500*2250 km domain; centre 54.5º N, 24.5º E.

*) HIRLAM model output as boundaries.

*) Organic matter, sulphate and black carbon AOD from CTM-IFS hindcast experiments (Huijnen et al., 2012) as input for HARMONIE radiation parameterization (IFS scheme is used).

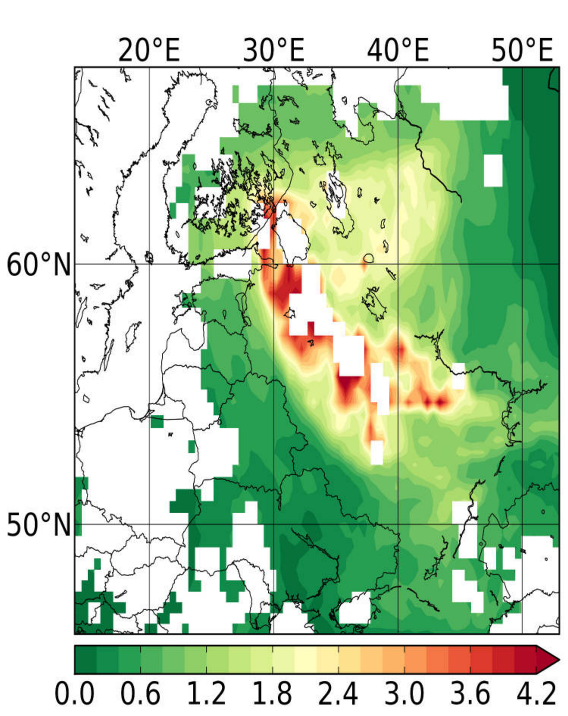


**Figure 2.** Smoke aerosol AOD from MODIS Terra 08.25 UTC.

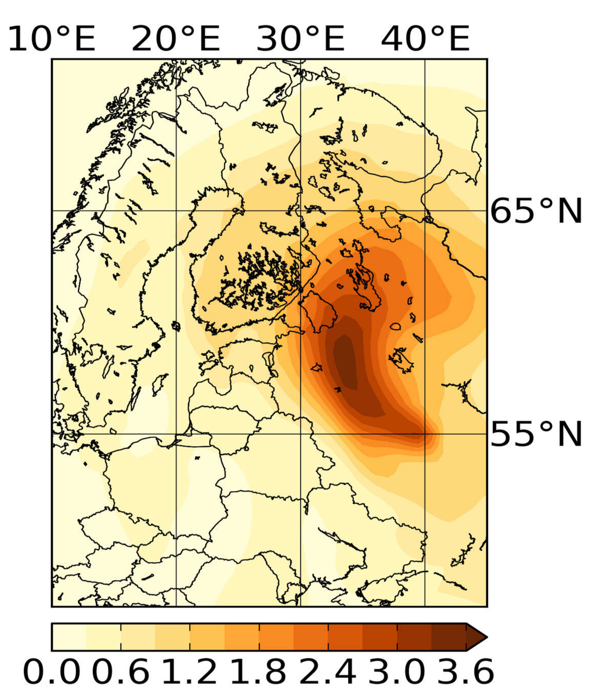


**Figure 3.** 24h average total aerosol optical depth (Huijnen et al., 2012).

## Modelling results

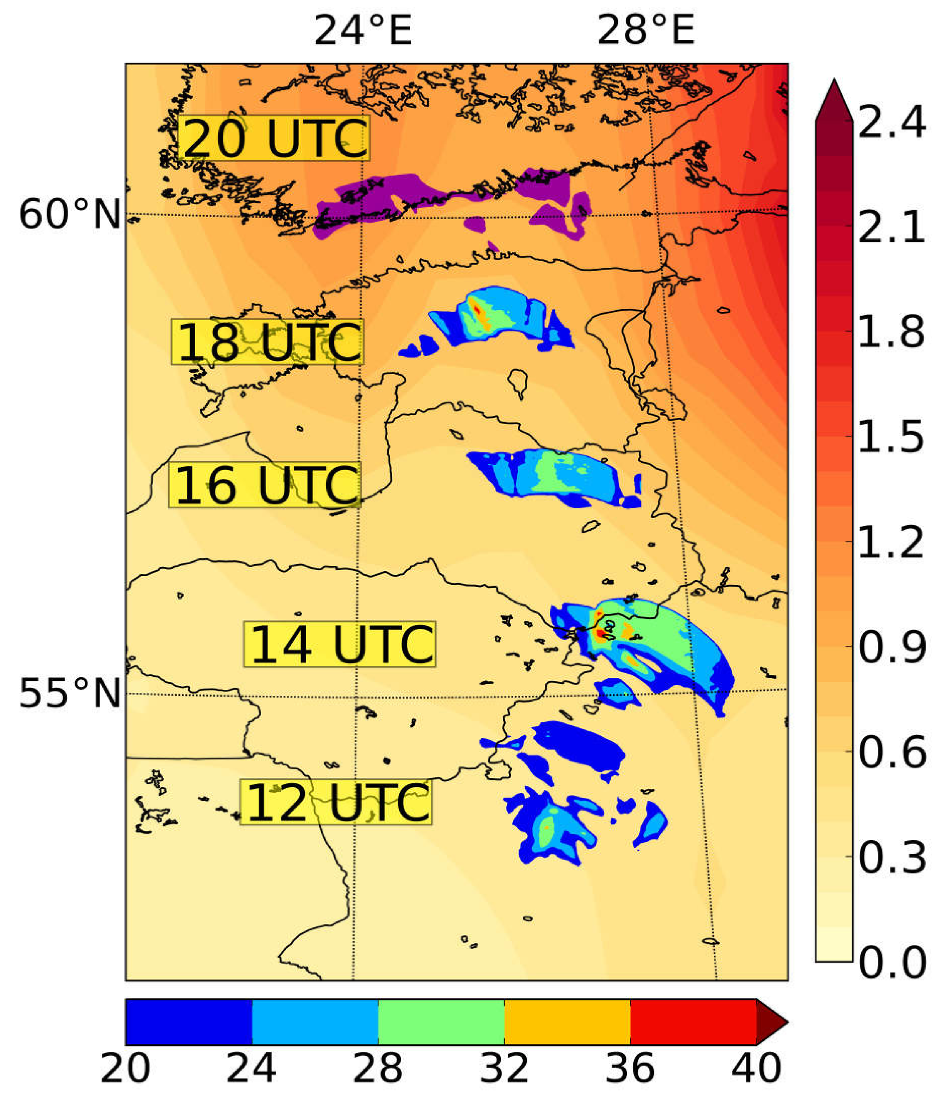


**Figure 4.** Thunderstorm path as determined by the simulated 10-m wind gusts (m/s) in last 30 minutes at 12, 14, 16, 18 and 20 UTC (colourbar below). Smoke aerosol optical depth (colourbar on right).

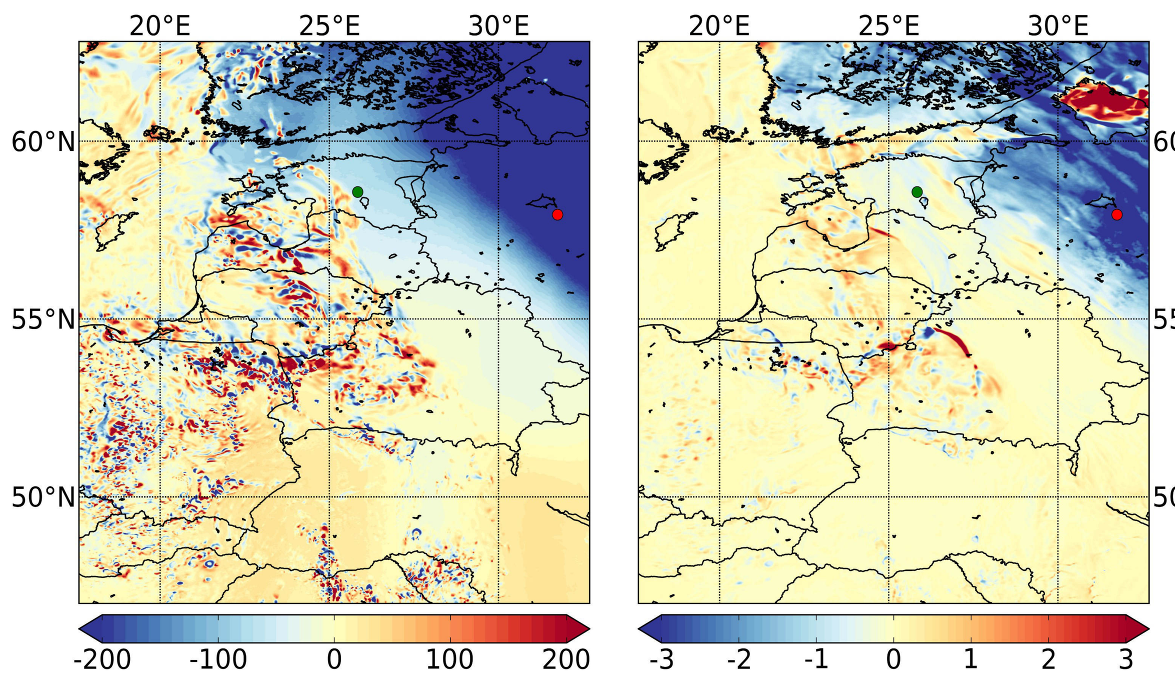


**Figure 5.** Shortwave radiation flux difference (W/m$^2$) at the surface in the left panel and temperature difference (ºC) at the lowest model level in the right panel resulting from smoke aerosol.

*) Reduction in the shortwave radiation flux at the surface simulated with the HARMONIE model resulting from the smoke aerosol direct radiative effect influence is up to 200 W/m$^2$.

*) Simulated near surface cooling is up to 3 ºC.

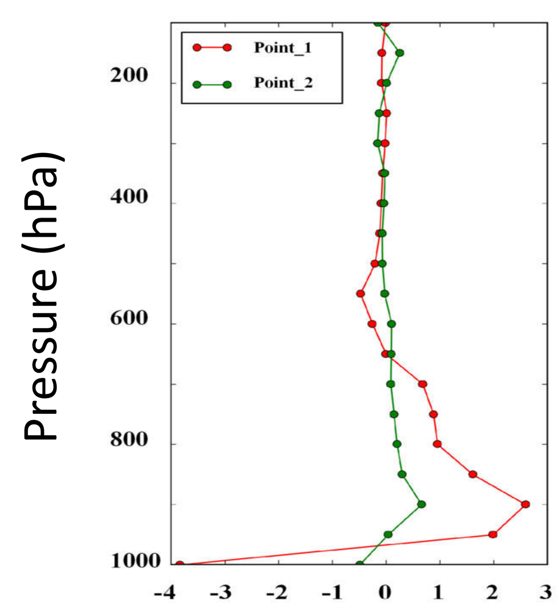


**Figure 6.** Temperature difference (ºC) resulting from smoke aerosol influence respectively in red and green dots at points marked with red and green dots in Figure 8 (12 UTC 08.08.2010).

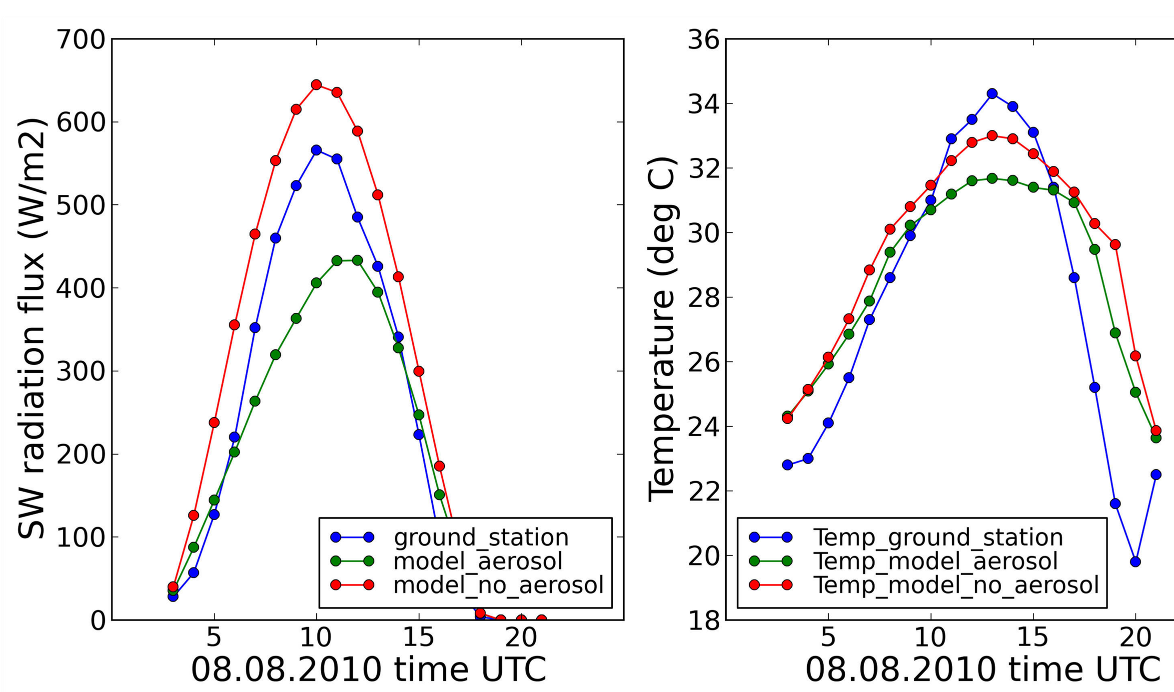


**Figure 7.** Simulated vs observed shortwave radiation flux (W/m$^2$) in the left panel and simulated vs observed temperature (ºC) in the right panel (both in the North-East Estonia 08.08.2010).

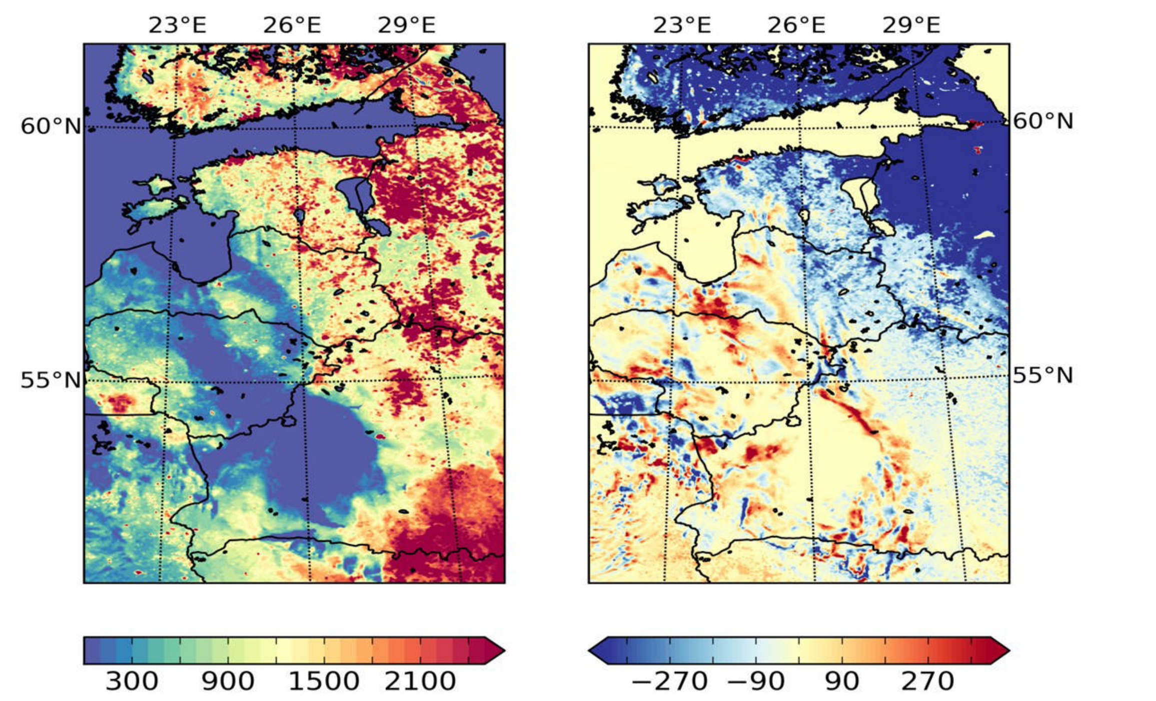


**Figure 8.** Simulated convectively available potential energy (J/kg) in the left panel and difference in the convectively available potential energy (J/kg) resulting from aerosol influence in the right panel (+12h simulation).

*) Atmospheric instability is decreased because of the aerosol radiative forcing.

*) The simulated thunderstorm is weakened because of the aerosol influence.

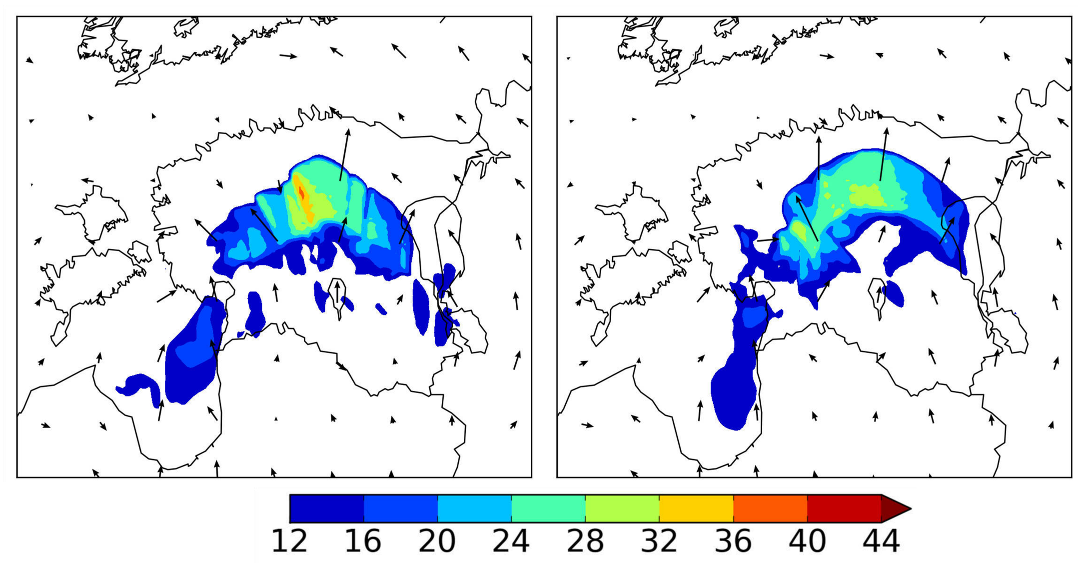


**Figure 9.** Simulated 10-m wind gusts (m/s) in last 30 minutes at 18 UTC without smoke aerosol influence in the left panel and with aerosol influence in the right panel.

## Conclusions

Severe thunderstorm in the Baltic Sea region on 08.08.2010 was weakened through direct radiative effect of smoke. Smoke reduced shortwave radiation at the ground up to 200 W/m$^2$ and decreased near ground temperature up to 3 ºC. Radiative forcing of the smoke seems to be overestimated as seen from the comparison with in situ radiation measurements and diurnal cycle of near ground temperature is not very well represented by the model. Impact of vertical distribution of aerosol needs to be investigated further.

## Acknowledgements

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## References

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